

# Atmospheric seasonal forecasts of the 20<sup>th</sup> Century: Multi-decadal variability in predictive skill of the winter NAO

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Welcome to your preview of The Times

## Forecasters crack formula to predict long-range weather

Article

Pictures

Catalysts for change



Paul Simons and Hannah Devlin  
Last updated at 12:01AM, April 2 2014

Extreme winters will be predicted with greater reliability than before after the world's best long-term weather forecast model was developed by British scientists, the Met Office said.

The breakthrough may have a substantial impact on the economy, allowing power companies and wind farms to anticipate energy demands while airports and councils can estimate how much grit and anti-freeze is likely to be required.

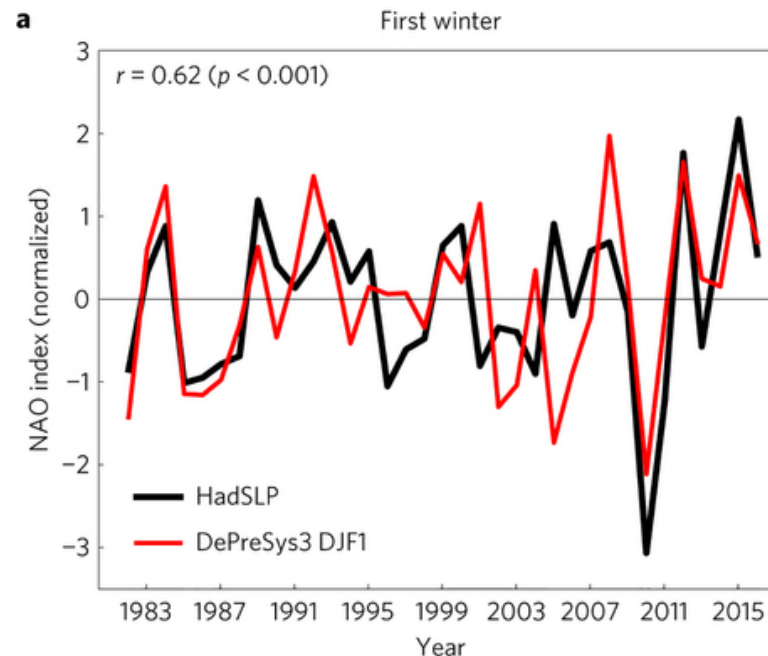
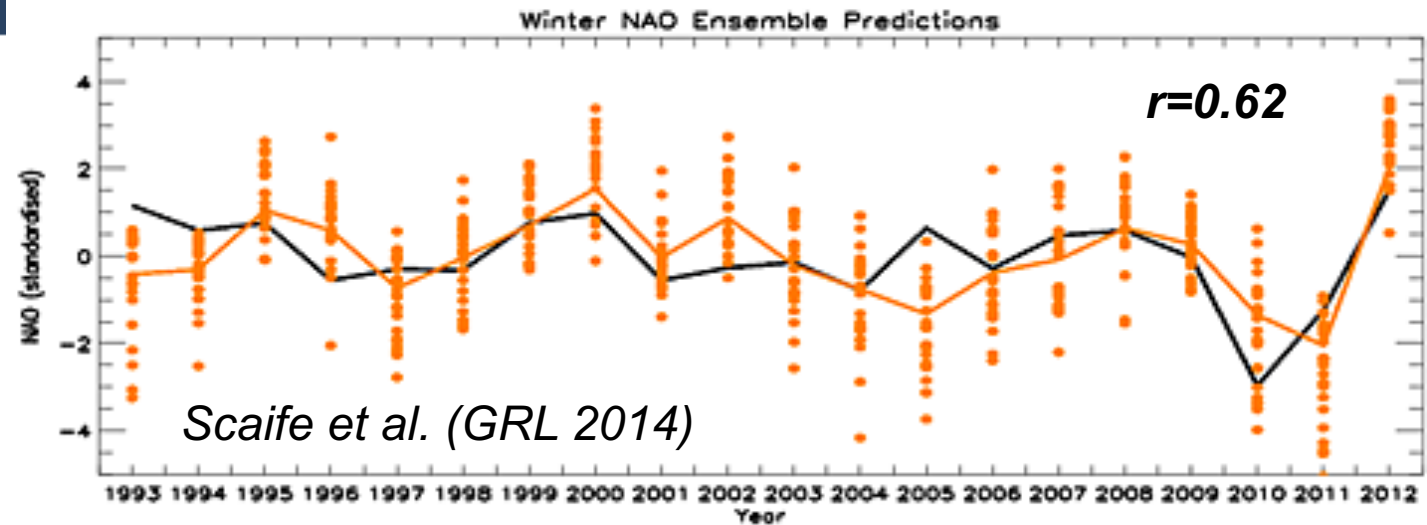
Daffodils were blooming in Whitegate, Cheshire  
Christopher Furlong/Getty Images

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## Seasonal forecasts of the winter NAO with the UK Met Office model



*Dunstone et al.  
(Nature Geo. 2016)*

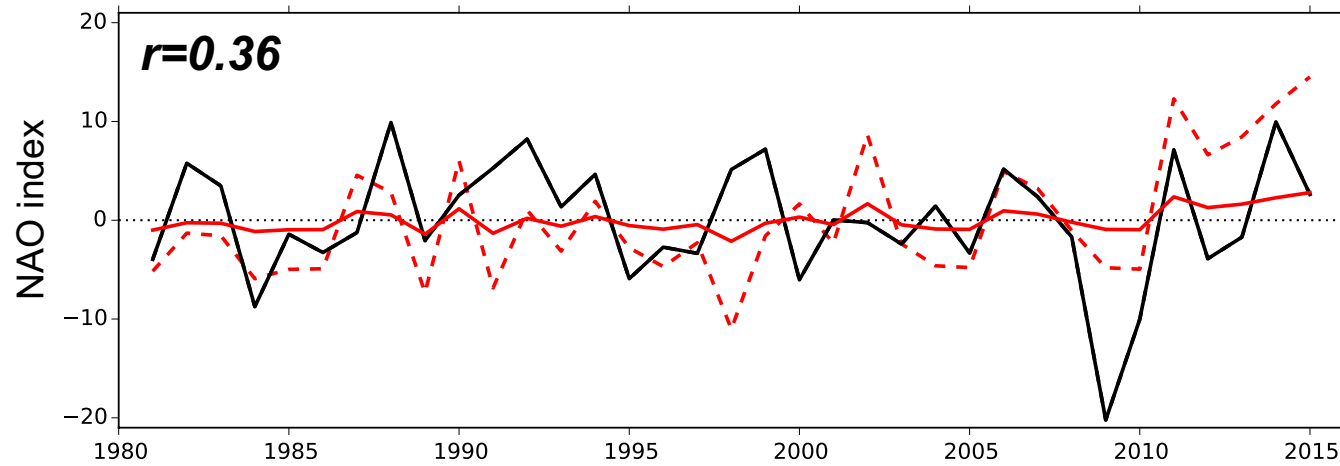
## Seasonal forecasts of the weather and climate over Euro-Atlantic region are difficult due to

- low signal-to-noise ratios in predictability of extratropical atmosphere
- teleconnections from tropical forcings are less direct, and perhaps more manifold, than for other areas in the world
- sample sizes are intrinsically small (mainly limited by number of observed seasons, usually  $O(30)$ )

**Estimates of seasonal predictability, skill and reliability suffer from rather large uncertainties.**

# Seasonal forecasts of the winter NAO

How big is the signal really?



*courtesy Stephanie Johnson, ECMWF*



# Seasonal forecasts of the winter NAO

## How unprecedented is the skill really?

Müller et al.: Probabilistic seasonal prediction of the winter North Atlantic Oscillation and its impact

**Table 4** Same as Table 3 but for all DEMETER models and the multi-model ensemble (DEM) for lead time of 1 month. Shown are the results for the period 1987–2001 and 1959–2001

	DEM	CNRM	SMPI	UKMO	SCWF	SCNR	LODY	CRFC
<u>1987–2001</u>								
NAO	<b>0.67(0.01)</b>	0.10 (0.71)	0.10 (0.74)	0.01 (0.9)	0.56 (0.3)	0.13 (0.6)	<b>0.61(0.02)</b>	<b>0.64(0.02)</b>
NAO-impact	0.37 (0.19)	0.01 (0.98)	0.05 (0.86)	0.14 (0.69)	0.49 (0.07)	0.06 (0.84)	0.40 (0.15)	0.24 (0.4)
<u>1959–2001</u>								
NAO	0.01 (0.9)	0.19 (0.24)		−0.29 (0.11)	0.05 (0.9)			
NAO-impact	0.17 (0.25)	0.31 (0.06)		−0.08 (0.61)	0.14 (0.35)			

*Müller et al. (Clim. Dyn. 2005)*

# Seasonal forecasts of the winter NAO

## How unprecedented is the skill really?

**Table 1.** NAO Correlations Between Model Ensemble Mean and Observations Based on Z500 (MSLP) for Different Hindcast Periods<sup>a</sup>

	<i>E_ECMF</i>	<i>E_UKMO</i>	<i>E_KIEL</i>	<i>E_INGV</i>	<i>E_MEFR</i>
1960–1979	−0.16 (−0.35)	0.03 (0.17)	0.12 ( <b>0.60</b> )	0.03 (−0.39)	0.07 (0.19)
1980–2001	0.20 (0.35)	0.02 (−0.08)	−0.07 (0.11)	0.22 (0.30)	0.35 (0.33)
1960–2001	0.07 (0.08)	−0.02 (0.00)	−0.08 (0.26)	0.10 (−0.02)	0.21 (0.26)
	<i>D_MEFR</i>	<i>D_ECMF</i>	<i>D_UKMO</i>		
1960–1979	0.26 (0.35)	−0.42 (0.10)	−0.05 (− <b>0.47</b> )		
1980–2001	<b>0.59</b> (0.32)	<b>0.45</b> (−0.05)	0.21 (0.02)		
1960–2001	<b>0.38</b> (0.20)	−0.12 (−0.06)	−0.15 (−0.27)		

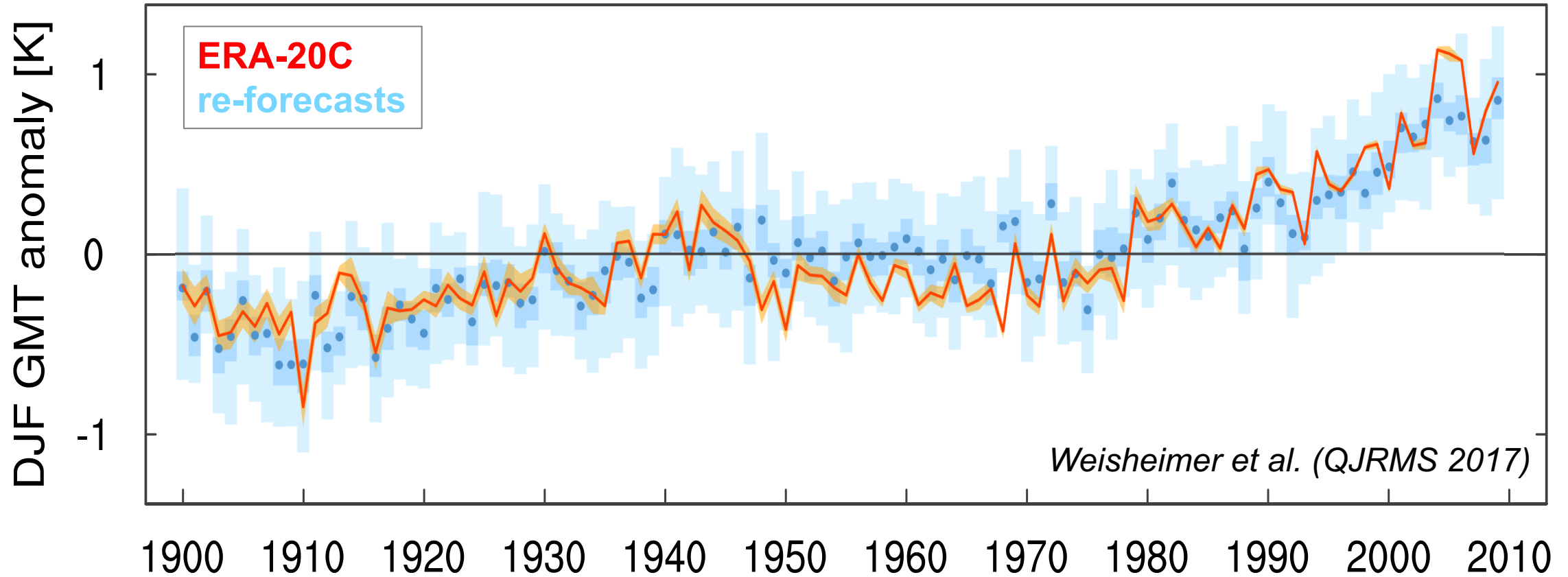
<sup>a</sup>The first part shows results from the ENSEMBLES models. The second part shows results from the DEMETER models. Correlations where a *t* test suggests significance at the 95% level are marked in bold.

# What insight could substantially longer sets of seasonal hindcasts provide about forecasting the future?

## Methodology:

- use ECMWF's re-analysis of the 20<sup>th</sup> Century (ERA-20C) that spans the 110-year period 1901 to 2010 to initialise atmospheric seasonal forecasts with ECMWF's forecast model
- SSTs and sea-ice are prescribed using HadISSTs
- seasonal re-forecast experiments over the period 1900-2010
- 4-month forecast started on 1<sup>st</sup> of Nov each year to cover boreal winter season
- large ensemble of 51 perturbed members

## Global mean 2m temperature forecast anomalies in DJF

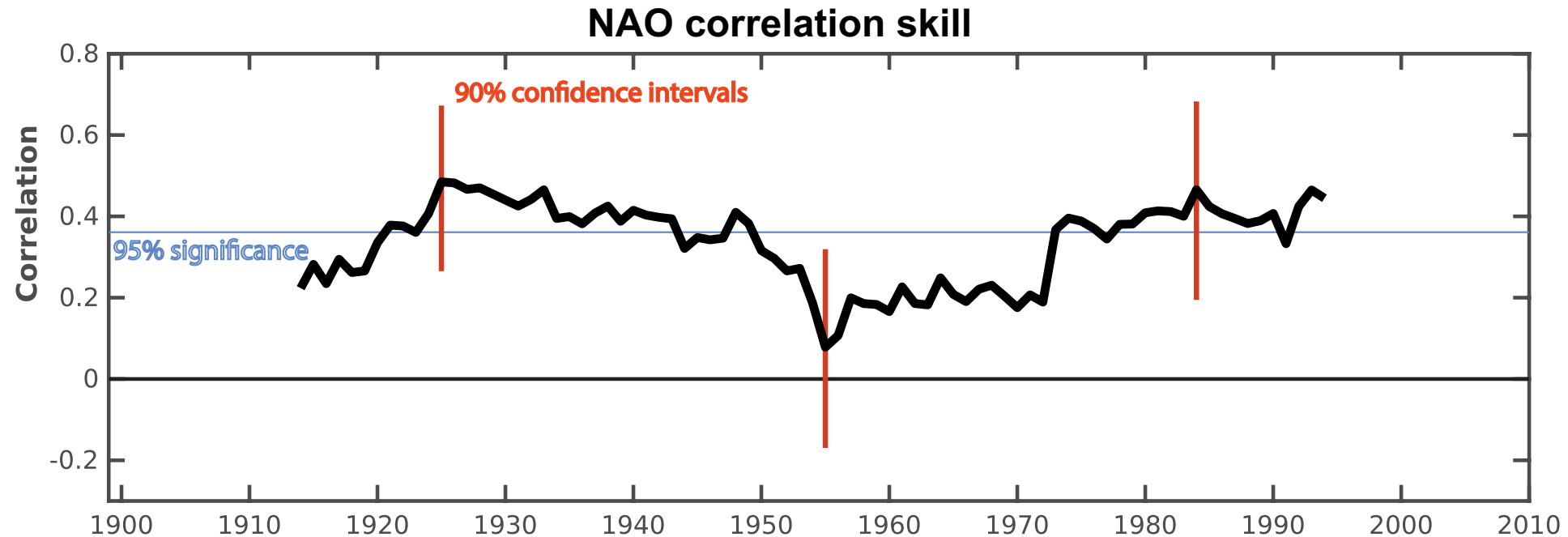


DJF global mean 2m temperature in ERA-20C (red) and the re-forecast ensemble of ASF-20C (blue). Uncertainty estimates from the reanalysis and the re-forecast ensemble are shown in orange (full range of the 10-member ensemble) and with blue shades (light blue: full range; darker blue: interquartile 25%-75% range; blue dots: ensemble median), respectively.

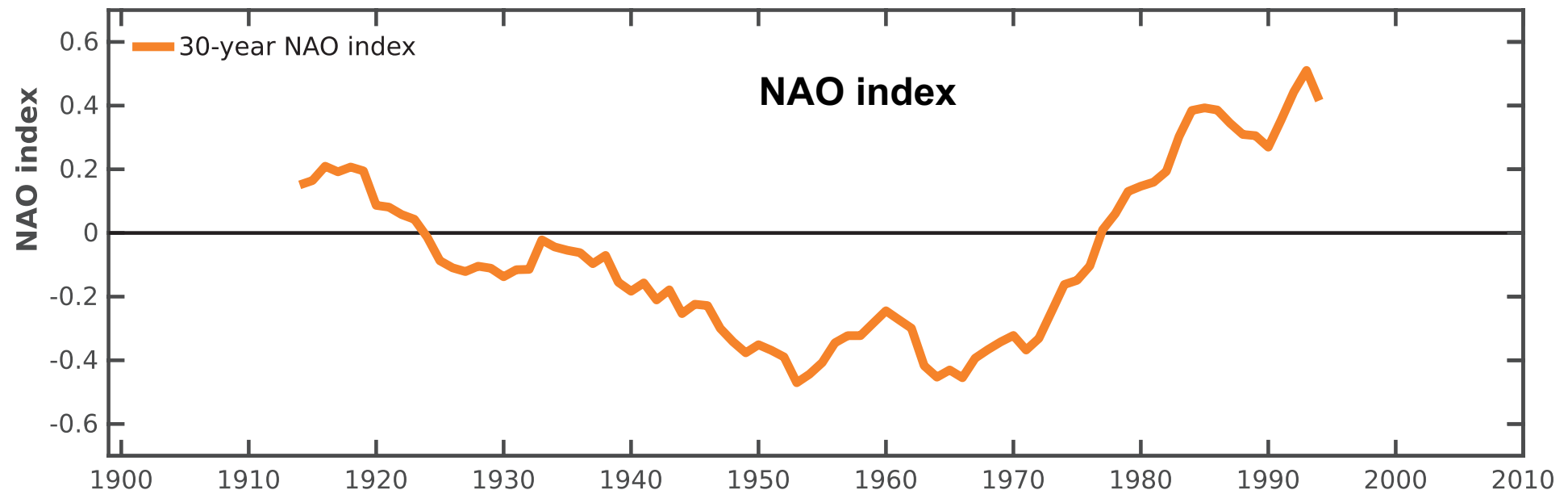
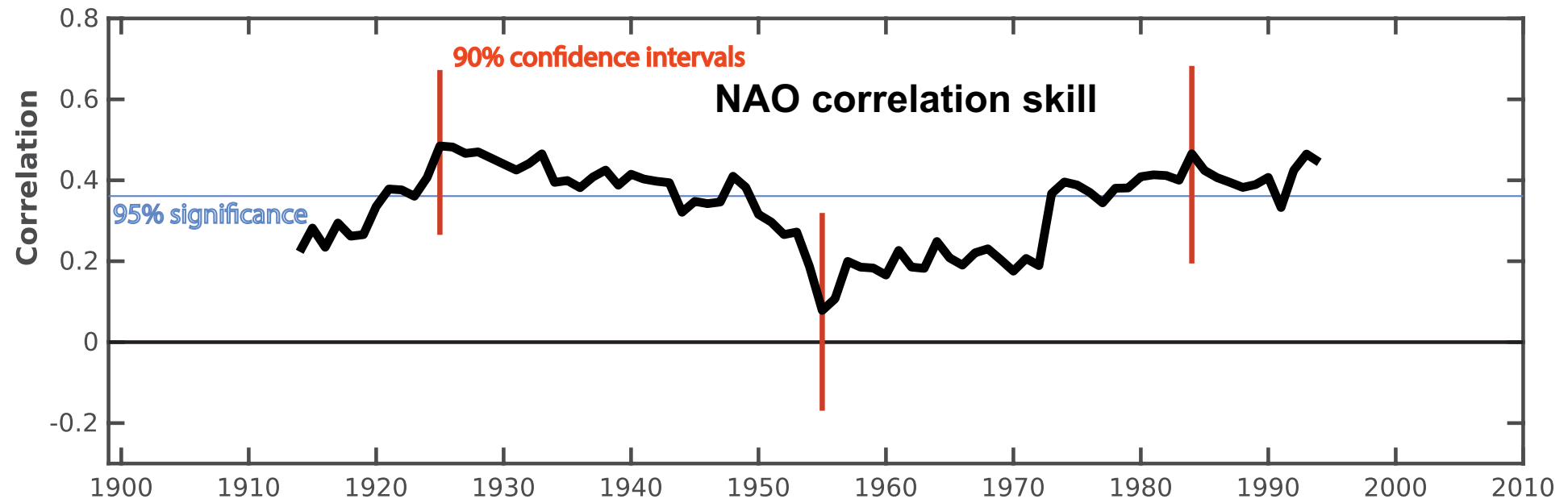


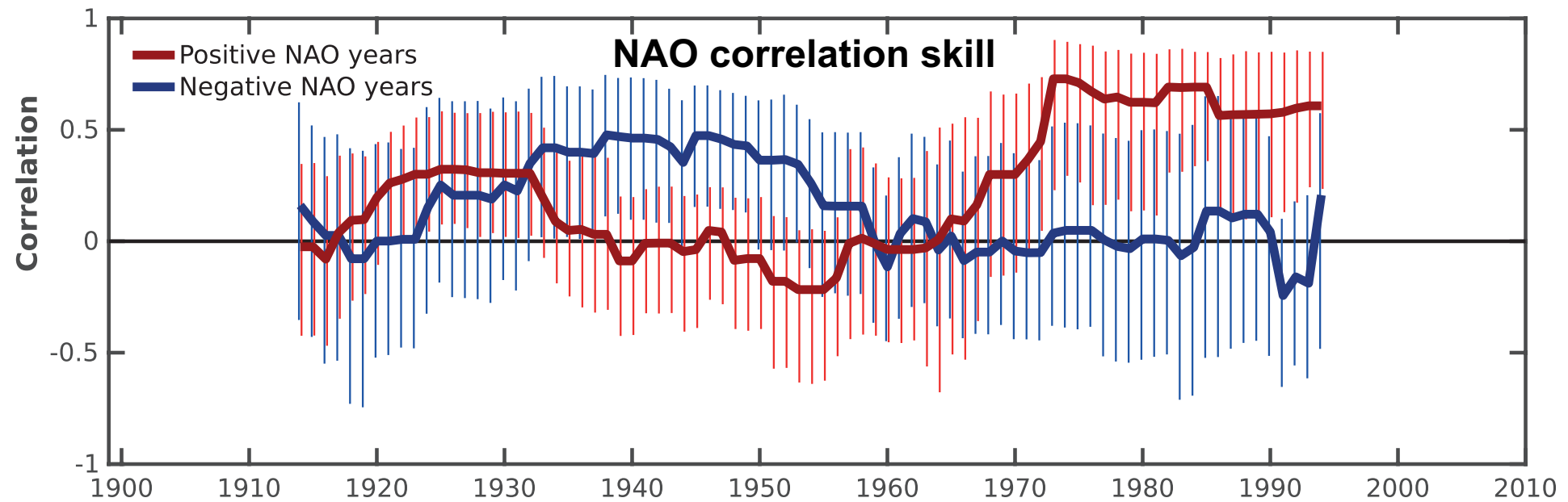
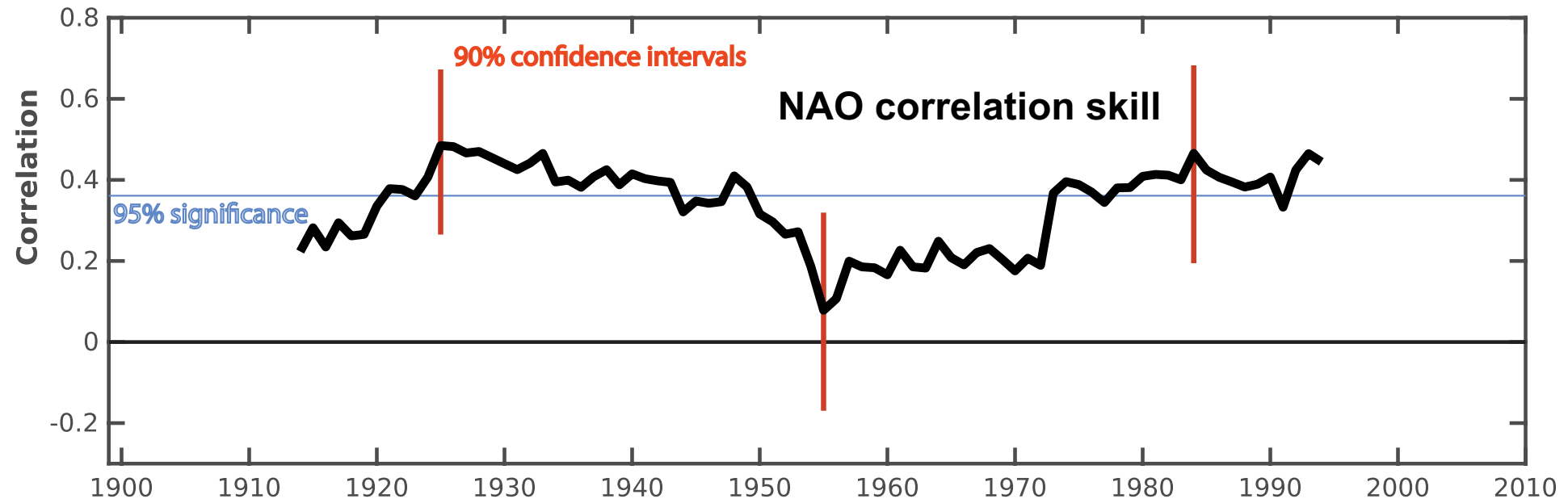
# Multi-decadal variability of NAO forecast skill

- estimates from 30-year moving windows -



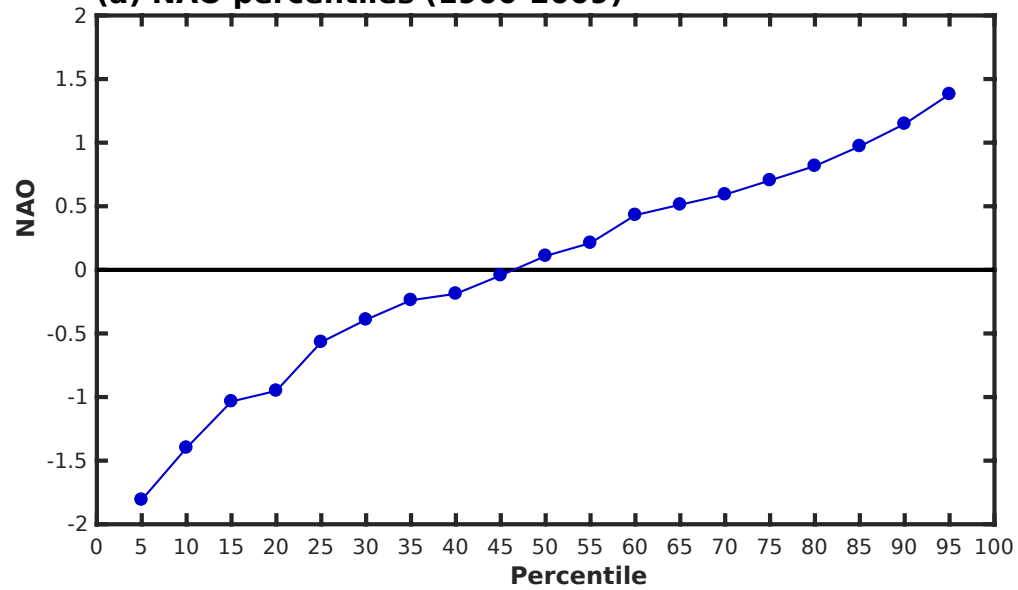
Anomaly correlation coefficient of the DJF NAO index between the ensemble mean and ERA-20C computed for moving 30-year windows by one year. Values are plotted at the 15th year of each window. The horizontal line indicates the  $t$ -test 95% significance level of the correlations and the red vertical bars show 90% confidence intervals estimated from bootstrap re-sampling (1000 times) with replacement for three representative periods.



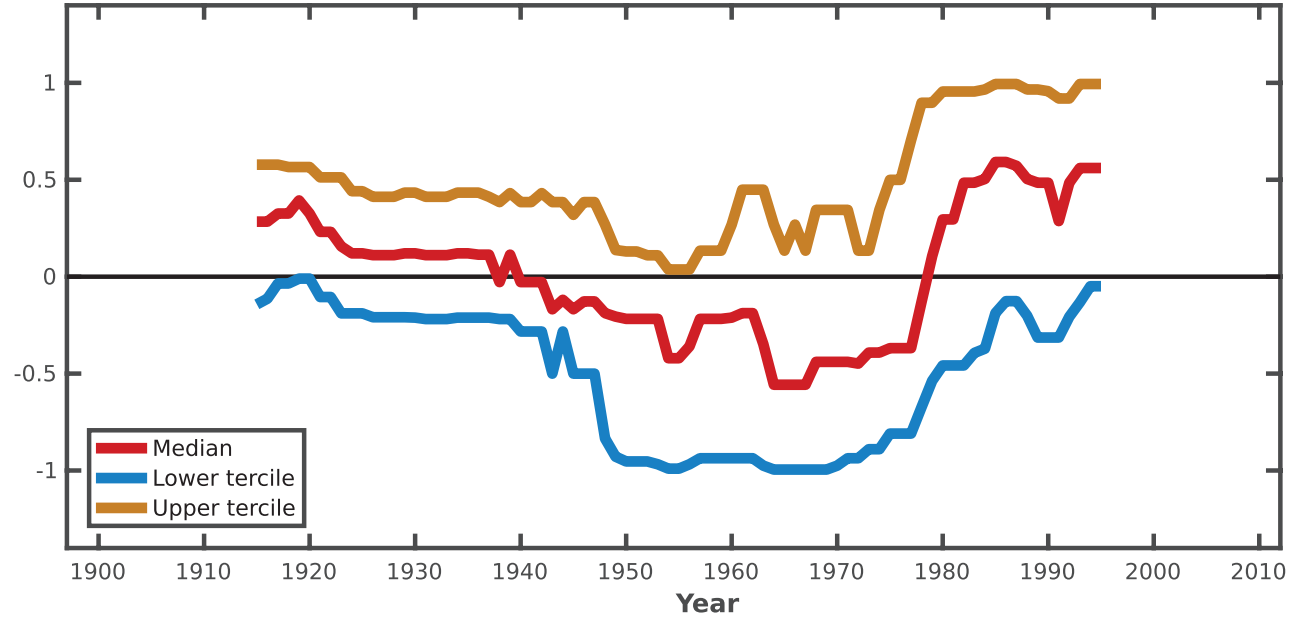


# ROC skill scores and NAO distribution

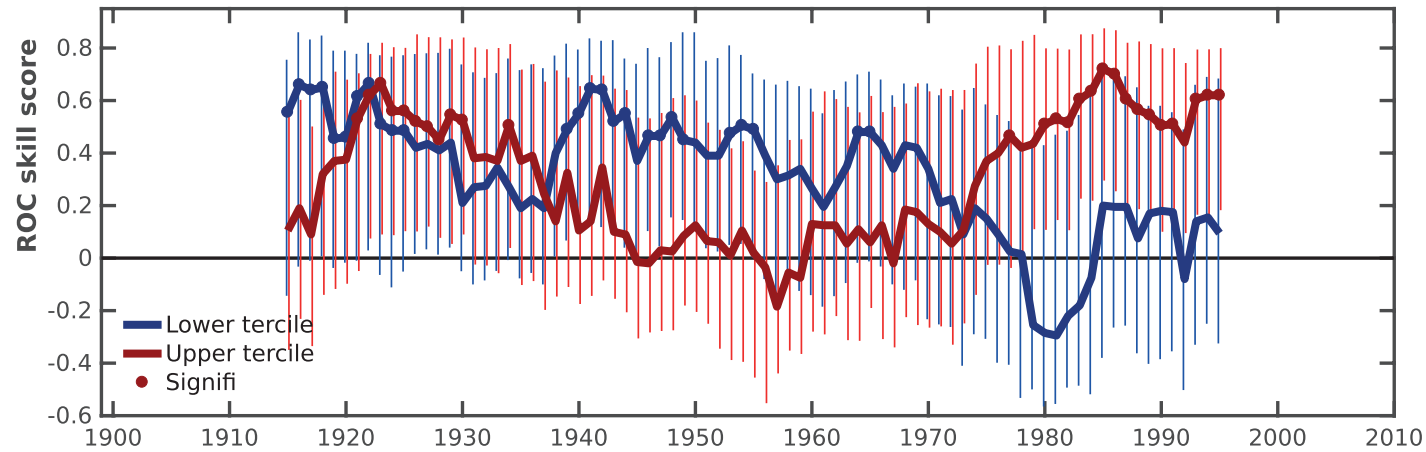
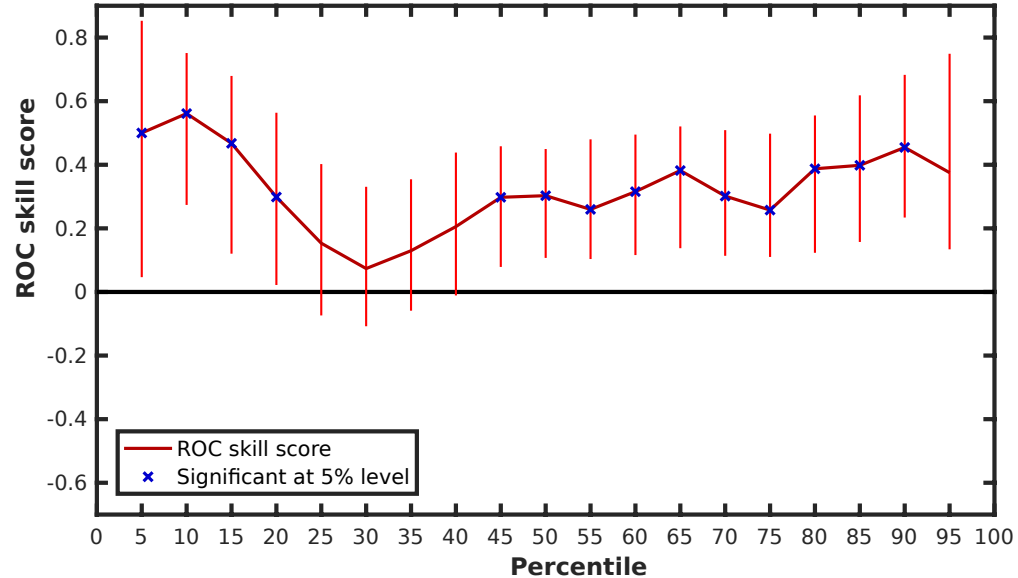
(a) NAO percentiles (1900-2009)



30-year running NAO thresholds (from ERA-20C)

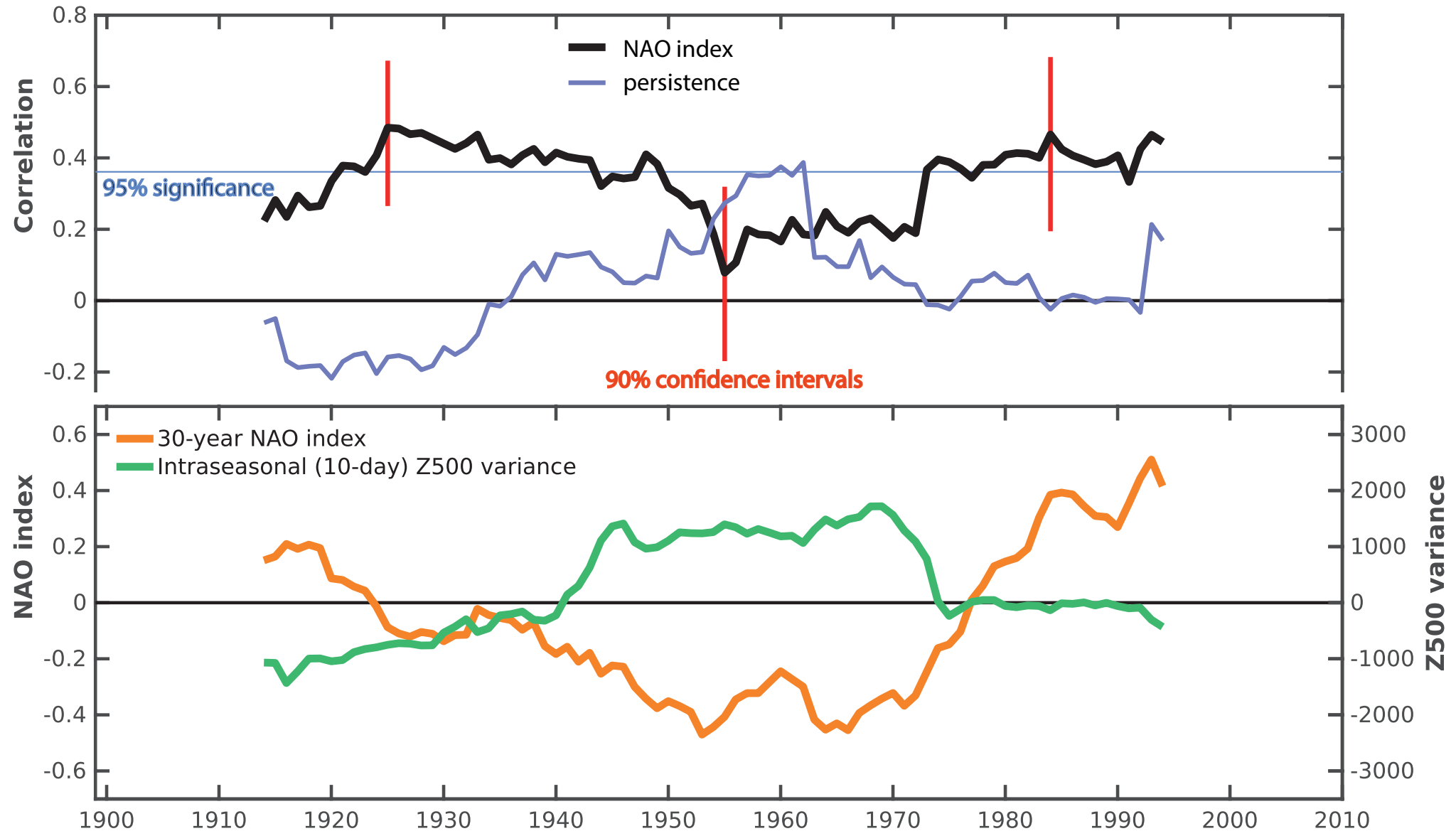


(b) ROC skill score (1900-2009)



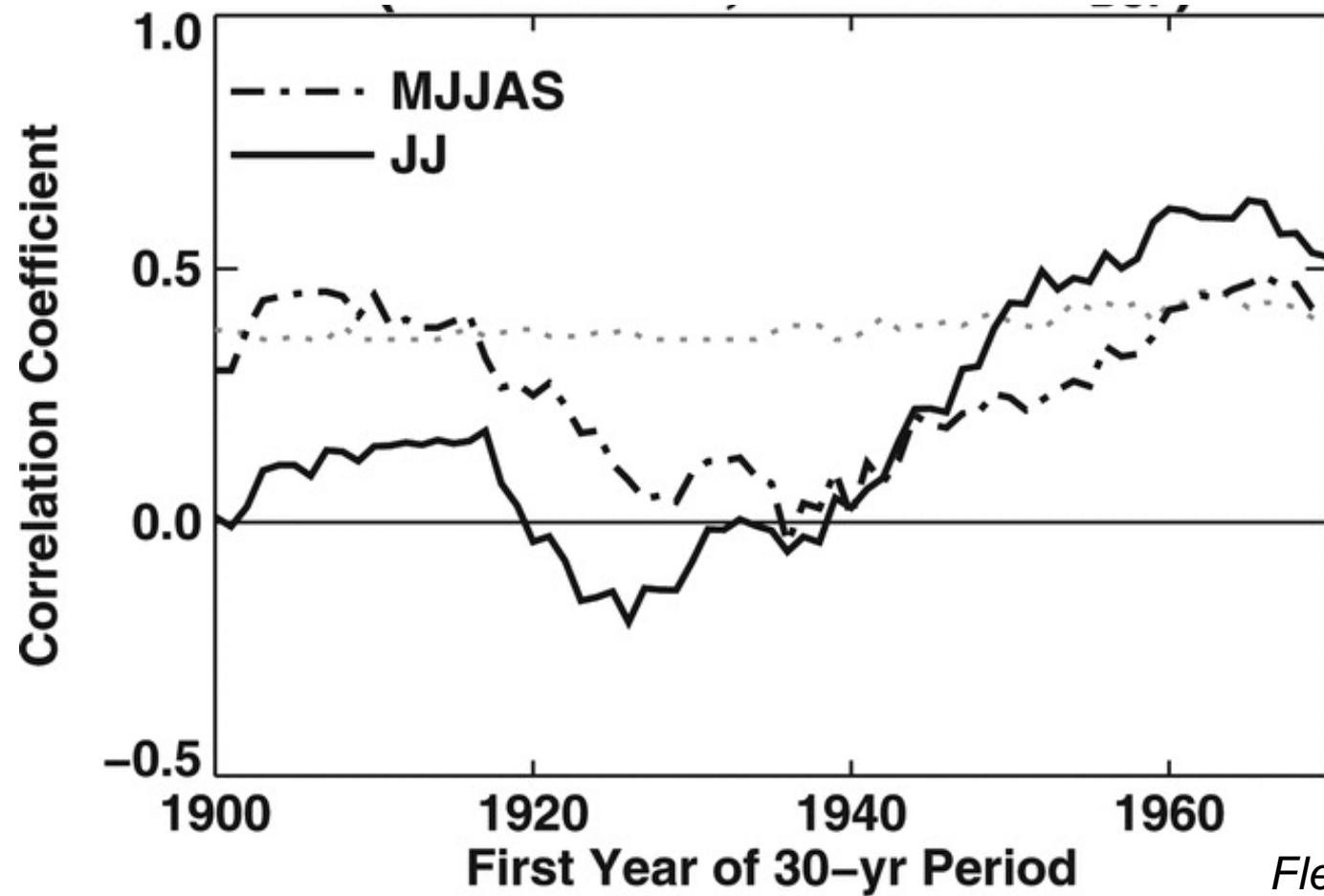
# Multi-decadal variability of NAO forecast skill

- persistence and intraseasonal variability -



## Multi-decadal variability of NAO forecast skill

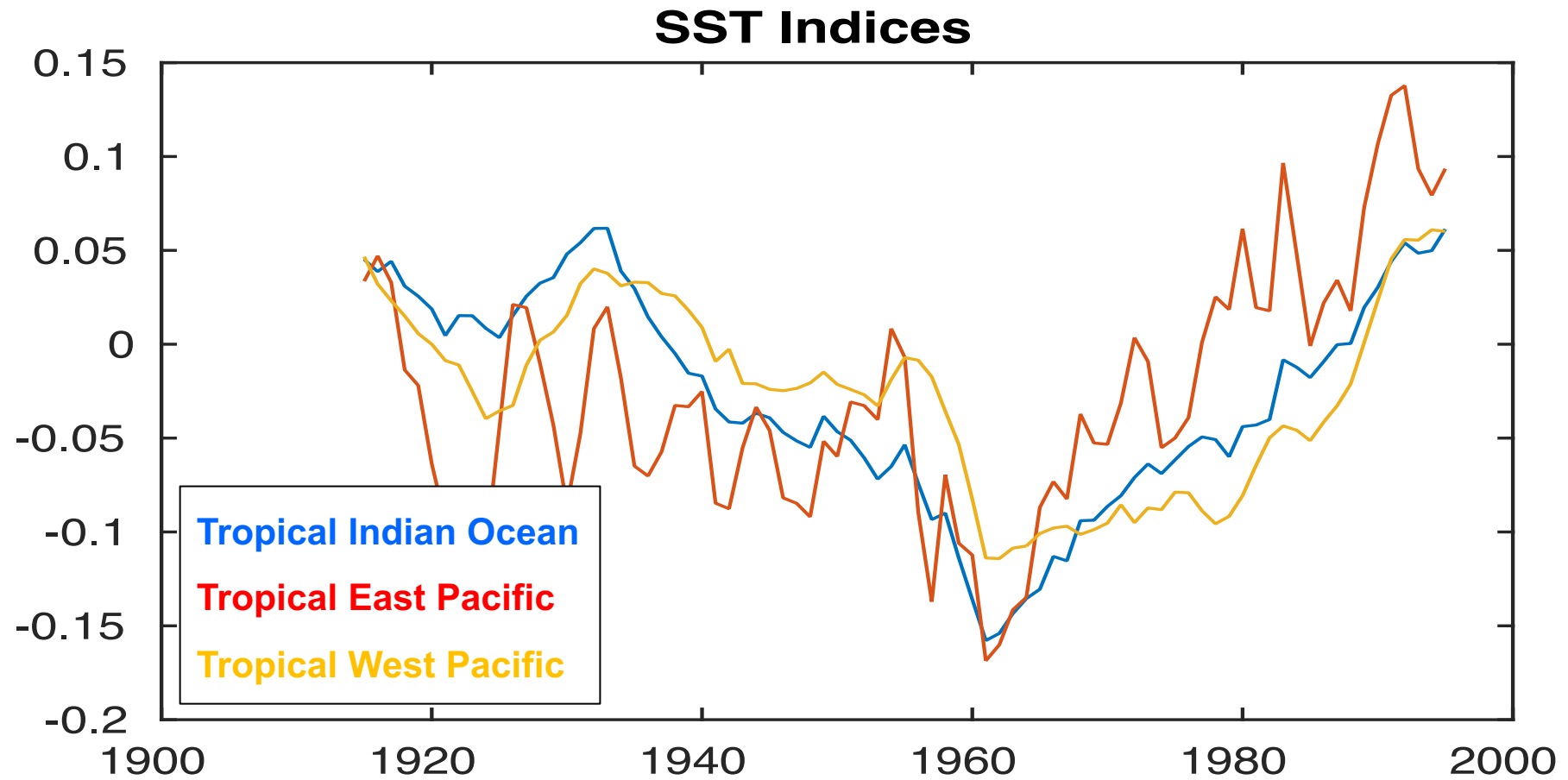
- statistical predictions -

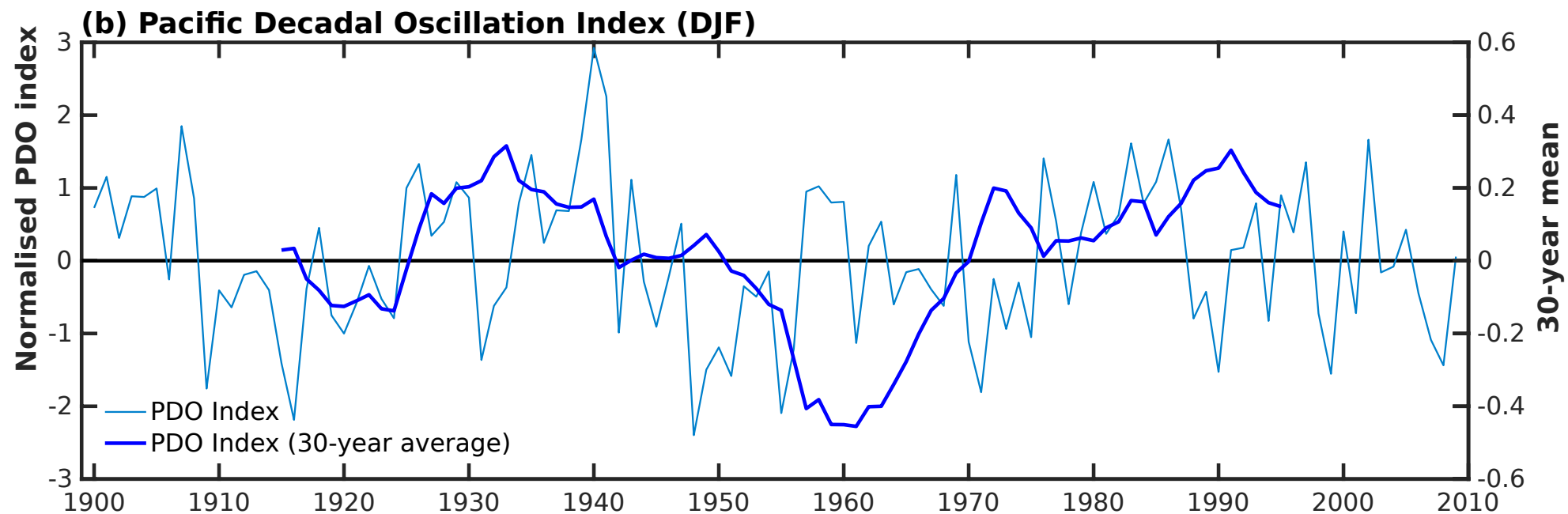
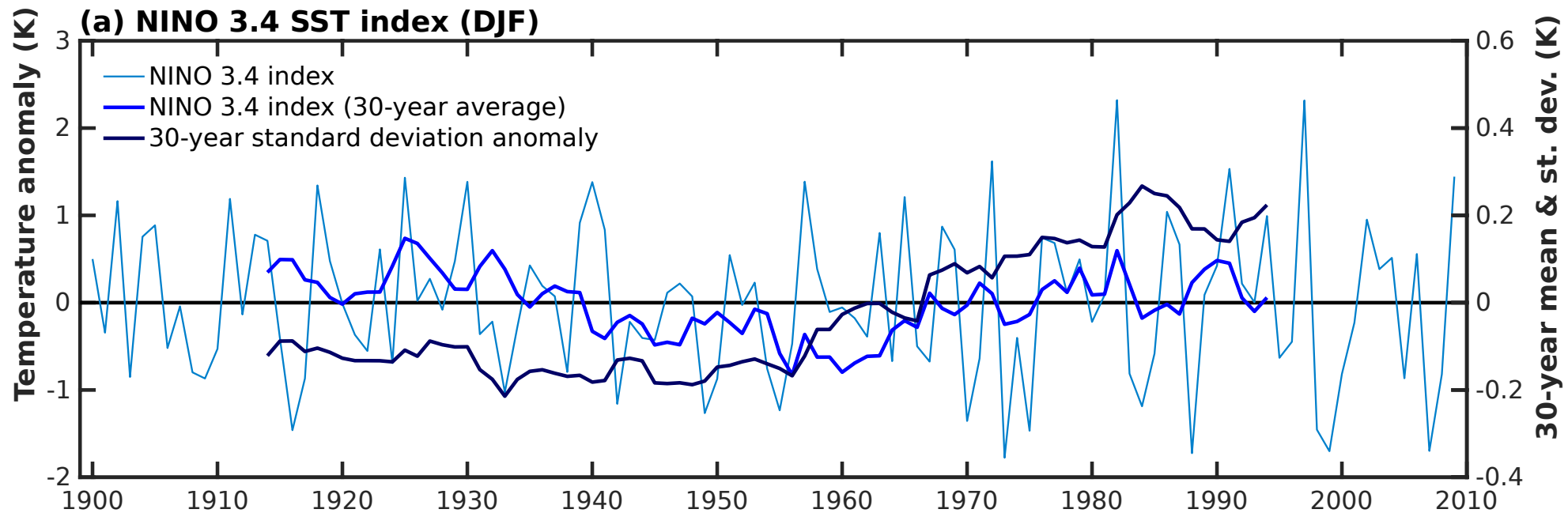


*Fletcher & Saunders (J. Clim. 2006)*

Correlation coefficients between the JJ and MJJAS  $T_{SP}$  indices and the upcoming CRU  $NAO_{DJF}$  index for running 30-yr windows commencing 1900–71. Faint dashed line indicates 5% significance level corrected for serial correlation.

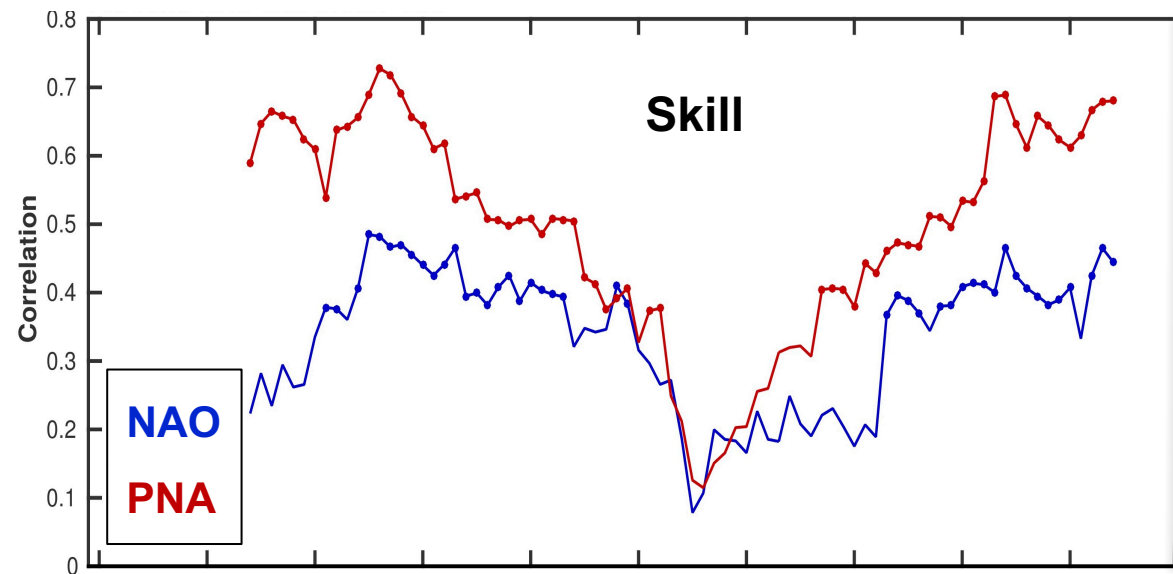
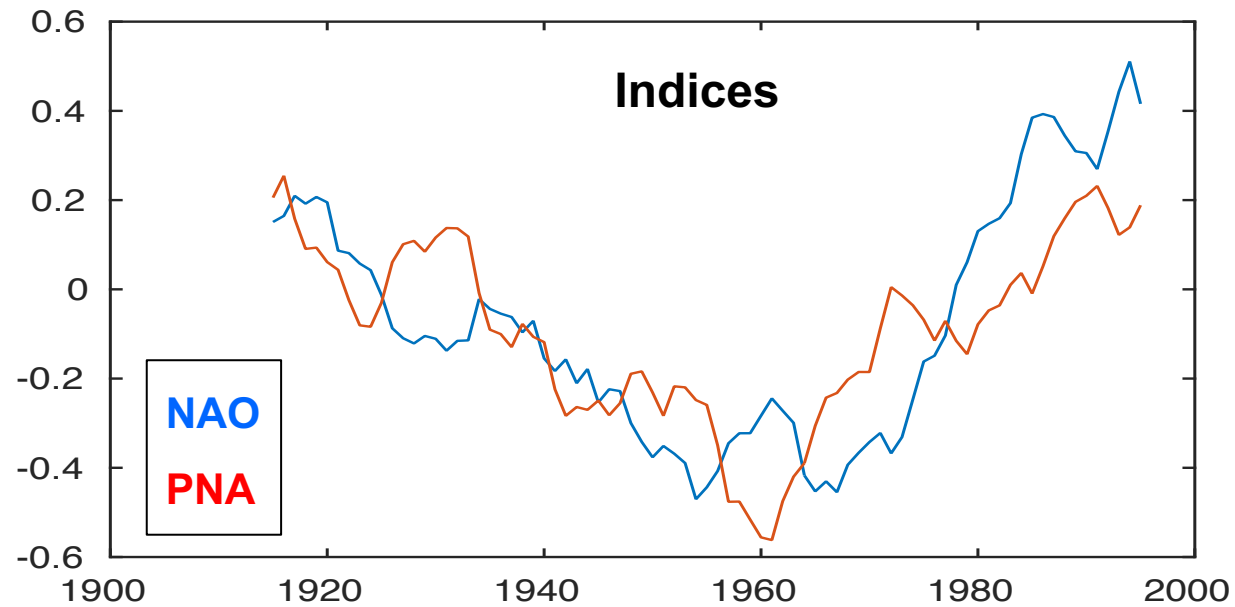
## Role of tropical forcings?







# Multi-decadal variability of the PNA and its forecast skill



See also:  
O'Reilly et al. (GRL 2017, accepted)

## Summary

- Dynamical predictions of the winter NAO remain a challenge
- New atmospheric seasonal forecast data set over the 110-year hindcast period 1900-2010
- Positive and significant skill in predicting the NAO index for DJF over the entire period
- Distinct multi-decadal variability of winter NAO forecast skill
  - No general evidence that model cannot predict negative NAO winters but asymmetry in predictive skill of NAO phases
  - Lack of skill in mid-Century: Flow-dependent non-linear model error or lower intrinsic predictability of the atmosphere?

**Mid-Century period stands out as an important period on which to test the performance of future seasonal forecast systems**

**Achieving good forecast skill for recent decades, with predominantly positive NAO winters, is not sufficient to guarantee similar good performance for possible periods with more negative NAO winters in the future**

- Remarkable co-variability of NAO forecast skill with PNA behaviour
- Role of remote tropical drivers of extratropical predictability?

## References

- Weisheimer, A., N. Schaller, C. O'Reilly, D. MacLeod and T.N. Palmer. Atmospheric seasonal forecasts of the twentieth century: multi-decadal variability in predictive skill of the winter North Atlantic Oscillation (NAO) and their potential value for extreme event attribution. *Q. J. Meteorol. Soc.* (2017), doi:10.1002/qj.2976.
- O'Reilly, C.H., J. Heatley, D. MacLeod, A. Weisheimer, T.N. Palmer, N. Schaller, and T. Woollings. Variability in seasonal forecast skill of Northern Hemisphere winters over the 20th Century. *Geophys. Res. Lett.* (2017), just accepted.